

# **PRODUCTION BIOLOGY OF PHYTOPLANKTON**

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## **LONG TERM GOALS:**

To review critically and creatively the knowledge about the interaction of bulk marine phytoplankton and zooplankton with the hydrographic and chemical environment, as well as the feedback from the planktonic processes to the abiotic environment, using existing observations and evaluations, as well as data collected by current programs. The understanding of the sea itself rather than the biology of marine organism is being stressed.

## **OBJECTIVES:**

The FY 1997 focus of my work was on regional oceanography, emphasizing the geographic and seasonal distribution of phytoplankton, as viewed from space in the upper one-quarter to one-third of the photic zone, in subpolar seas of both hemispheres and in the Arabian Sea. The underlying processes were principally considered as problems of population growth, rather than of physiology. In addition, I continued to be interested in discussions by the community of broad issues, like the iron hypothesis or JGOFS-related questions.

## **APPROACH:**

The work was based on raw data, as well as on the literature. New (i.e., so far not scientifically utilized) hydrographic observations (with oxygen) were largely used in consultation with the originators. Also, I utilized Nimbus-7 Coastal Zone Color Scanner (CZCS) data for phytoplankton pigment that were reprocessed under my direction (NASA-work from an expired grant).

For the hydrographic material, the principal tool was water mass analysis by t-S diagrams, utilizing also oxygen, while for the plankton, the principal tool was the integrated approach to the entire data set. The special twist was the ability to make statements about temporal (seasonal and interannual) changes, which previously usually were lacking from low-latitude studies, as they tended to be based on single sections of an expedition.

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## WORK COMPLETED:

1. The paper "Irregular Outflow of Persian (Arabian) Gulf Water to the Arabian Sea" was revised and is now in press in the Journal of Marine Research (Supported by ONR and NASA). The abstract is as follows:

The bottom outflow from the Persian (Arabian) Gulf, which intrudes in the Gulf of Oman as an intermediate salinity maximum and spreads in the northern Arabian Sea, was inferred to be seasonal. Also, based on particular expedition, single values of temperatures, salinities, and oxygen concentrations were assumed as end members for this core layer. From historical data it is shown here that the salinity of the water exiting at depth from the Gulf is first reduced to  $< 40$  ppt by mixing with Gulf of Oman water in the shallow Strait of Hormuz with its strong tides. The core layer acquires its characteristics when the mixing product descends the outer shelf at the head of the Gulf of Oman and entrains upper-thermocline water with an intermediate to low oxygen content above the outflow. After leaving the seabed, when mixing with water also below the intrusion begins, the maximal values observed in the core layer for salinity, density ( $\sigma_t$ ), and oxygen saturation ranged between 37.5 and 38.0 ppt, 26.30 and 26.95 g dm<sup>-3</sup>, and approximately 20 and 60 %, respectively (eight expeditions, with two for oxygen; in all, 15 temporally separated cruises). Rules about this variability could not be recognized, except that the oxygen content in the freshly formed core layer seems to be highest in spring and lowest in fall.

At the head of the Gulf of Oman, one intrusion was always present; at least three times, two intrusions of nearly the same density were encountered, as is common also several 100 km away from the source region. Persistent presence of the core layer at the head, but absence near the mouth of the Gulf of Oman in the spring of one year and presence during the following spring (five cruises between May 1975 and August 1976) do not indicate a marked seasonal pattern of the outflow. Within at least 1,000 km from the Strait of Hormuz, advection clearly participates in the lateral spreading of the core layer.

2. The results of the previous re-processing of all Coastal Zone Color Scanner data from the Subarctic Pacific and the deep parts of the Bering Sea (under my direction, with NASA support) were drafted during this year with ONR support. The principal question, whether the little explored plankton dynamics of the western Subarctic Pacific and the deep parts of the Bering Sea function similarly as in the experimentally well-studied eastern Subarctic Pacific, is answered affirmatively. The entire region is one of the three High Nutrient-Low Chlorophyll regimes of the oceans.

3. With the help of Dr. S. Piontkovski from the Institute of Biology of Southern Seas (IBSS) of the Ukrainian Academy of Sciences in Sevastopol/Crimea, the drafts of ten commissioned papers about a comprehensive expedition of IBSS to the northwestern Arabian Sea during the northeast monsoon of 1990 (with notes about earlier work) were edited. The resulting revisions have been received in Seattle. The scope of the expedition extends from hydrography through nutrients, phytoplankton, heterotrophic bacteria, zooplankton including stages of copepods, myctophids (including stomach analyses), to squids. In contrast to the recent U.S. JGOFS studies in the same area largely performed along sections, this work was done on a very large grid with generally 30

-nm separation of stations. This will permit a quantitative three-dimensional spatial treatment (e.g., the role of eddies) which, however, is not attempted in all of the manuscripts. (The translation of a unpublished manuscript for a similar expedition of 1980 to the same area, including an atlas of about 100 maps, has just been launched [with U.S. JGOFS support].)

Commissioned translations from the Russian are at hand and are being edited for:

L.I. Sashina (deceased). 1985. Nauplii of Dominant Pelagic Copepods in the World Ocean. Naukova Dumka, Kiev. 237 pp. with 100 figures and 2 tables.

L.I. Sashina (deceased). 1987. Reproduction, Growth, and Production of Marine Copepods. Naukova Dumka, Kiev. 155 pp. with 35 figures and 55 tables.

### **IMPACT:**

I continue to utilize old data never studied before or not fully treated by the originators, in order to elucidate the regional oceanography of the Arabian Sea and other areas. The result, usually, is a new look at an old question, and/or an integration not previously achieved.

### **RELATED PROJECTS:**

Collaboration with colleagues at the National Institute of Oceanography (India) in Goa and the Central Marine Fisheries Research Institute in Cochin (India) continues. It focuses on the hydrography including oxygen and on nitrogen metabolism on and off the shelf of the west coast of India. No material progress has been made since the last report, owing to my other commitments.